1. Introduction

In recent years, managers have come to appreciate the role of disturbances in shaping the structure and function of ecosystems. It has become clear that organisms are adapted to the disturbance regimes under which they evolved and that altering those disturbances regimes and reducing the natural variability in disturbance dynamics can have profound, and often unfortunate, consequences (Swanson et al. 1993; Morgan et al. 1994; Rogers 1996; Poff et al. 1997; Landres et al. 1999). For this reason, managers often seek to restore natural disturbance regimes.

In steppe vegetation of the Intermountain West, prescribed burning is often recommended as a means of accomplishing several objectives, including removing litter to enhance seedling recruitment; promoting plant vigor and site productivity; providing opportunities for species that require early seral stages; rejuvenating decadent stands containing large amounts of standing dead, leached vegetation; improving forage for wildlife and livestock; controlling exotic weeds; preventing shrub encroachment; enhancing structural diversity within habitats and landscape level diversity across habitats; decreasing the probability of severe fires in the future; and increasing ecosystem stability (McKell et al. 1962; Vogl 1974; Wright 1974; Peek et al. 1979; Antos et al. 1983; Adams 1989; Johnson 1989; Johnson et al. 1994; Fedrizzi 1998; Johnson 1998).

Fire management should maximize the beneficial effects of burning on native vegetation and minimize its negative effects. In order to do this, managers need to understand past disturbances and their consequences. This report reviews information about the nature, timing, and effects of fire on true steppe and meadow steppe communities of the northern intermountain region. This region, termed the northern section of the "*Agropyron spicatum*" Province by Daubenmire (1970), encompasses southeastern Washington, northern Idaho, northeastern Oregon, south-central British Columbia, and a disjunct area in northwestern Montana (Figure 1). Its climate is semiarid, with most precipitation falling in the cooler months (Figure 2), so that the region is characterized by summer drought (Weaver 1917; Daubenmire 1968*b*, 1972, 1978), although in some areas there is a secondary peak of precipitation in May and June (Tisdale 1986; Johnson and Simon 1987). Native steppe vegetation is dominated by perennial bunchgrasses accompanied by a microbiotic or cryptobiotic crust of mosses, lichens, algae, fungi, and cyanobacteria (Daubenmire 1942, 1970; Tisdale 1947, 1986; Cooke 1955; Poulton 1955; Mueggler and Stewart 1980; Johnson and Simon 1987; Mancuso and Moseley 1994; Lichthardt and Moseley 1997). The most common dominant grasses on zonal soils are bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata*, formerly *Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*). In mesic environments, the perennial grasses and cryptogams are accompanied by a variety of forbs growing between the perennial grasses as well as low thickets of rose (*Rosa nutkana* and *R. woodsii*) and common snowberry (*Symphoricarpos albus*). This type of vegetation is termed meadow steppe. As the environment becomes even more mesic to the north and east, meadow steppe gives way to dry coniferous forests dominated by ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) (Daubenmire 1970). To the west, the climate becomes more xeric, and shrub steppe (in which an overstory of big sagebrush,

Artemisia tridentata, accompanies herbaceous steppe vegetation) is the predominant type of vegetation.

Managers often want to restore historical disturbance regimes. In the northern intermountain region, there is considerable interest in using fire as a management tool to accomplish a variety of objectives in steppe vegetation, but there is a need for information about the historical role of steppe fires.

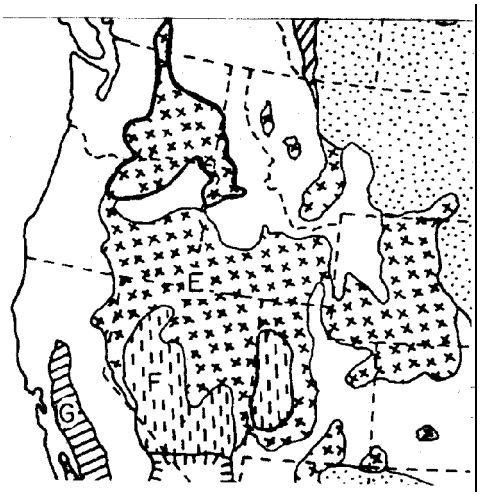

Figure 1. The northern section of the "*Agropyron spicatum*" Province (heavy black line). (After Daubenmire 1978).

2. Past fire regimes in northern intermountain steppe

2.1. Fire regimes prior to the arrival of Euroamericans

2.1.1. Naturally started fires

Information on past fires can be obtained from natural records, such as fire scars in tree trunks and charcoal deposits in sediment cores, as well as from historical records, such as journals, notes, sketches, and photographs. Because of the scarcity of woody material in steppe environments, historical records figure prominently in attempts to reconstruct their fire history. These materials provide a considerable amount of material pertaining to fire history, but they have some limitations (Nelson and England 1971; Gruell 1985; Swetnam et al. 1999). First, the events of some times and places are recorded in more detail than others. Whether or not an event was recorded depends upon chance (was an observer present in the right place at the right time?), interest (did the observer consider the event worth recording?), and opportunity (did the observer have the time and the equipment to record the event?). Cultural attitudes influence what an observer considers worth recording. Settlers may have been disinclined to record steppe

fires because they were considered less economically and ecologically important than forest fires (Daubenmire 1968*a*; Gruell 1985). Second, it is often difficult to determine the extent of the geographic area that is covered by an account. Third, documents can be hard to interpret because they are unclear or because the document has deteriorated. Finally, the reliability of the documentary record depends upon the skill and honesty of the people who recorded past events and the technical capabilities of the cameras or other equipment used.

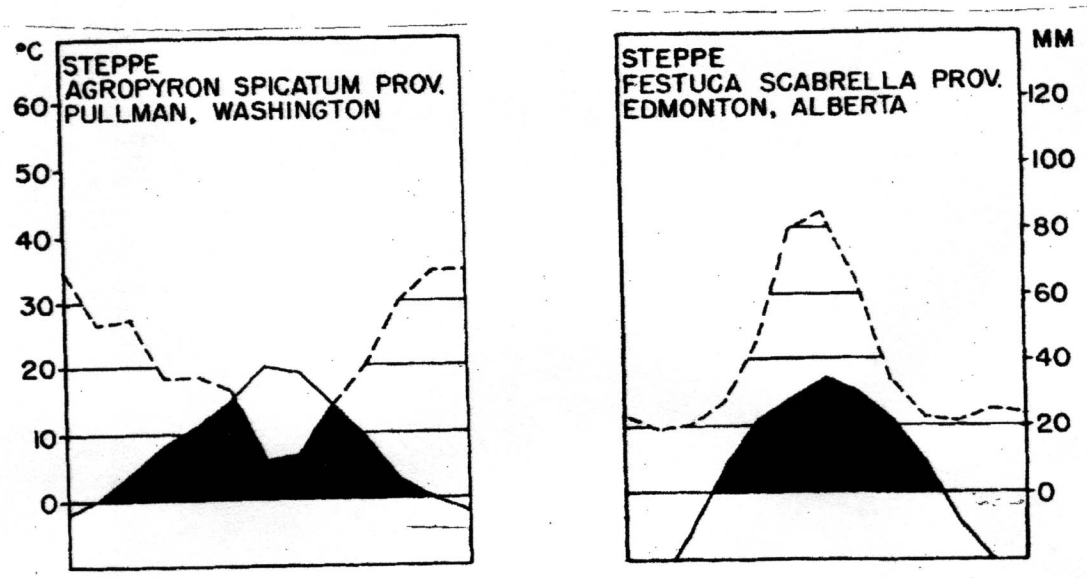

Figure 2. Seasonal distribution of mean monthly temperature and precipitation in the "*Agropyron spicatum*" Province. Solid line = temperature; dashed line = precipitation. Note that in the "A*gropyron spicatum*" Province precipitation is at a minimum in summer, whereas in the "*Festuca scabrella*" Province precipitation peaks in summer. (After Daubenmire 1978.)

When white settlers arrived in the intermountain region, naturally started surface fires were frequent in dry, low-elevation forests and forest-steppe ecotones (Arno 1976, 1980; Hall 1980; Arno and Gruell 1983; Gruell 1983; Agee 1993; Kinateder 1998). There is also evidence that fires were common in the steppes of the northern Great Plains (Nelson and England 1971), and fire may have been an important influence on the composition of shrub steppe vegetation (Burkhardt and Tisdale 1976), although vegetation was less likely to burn where fine fuels were in short supply (Peters and Bunting 1994). Little is known about the frequency of fires in the intermountain steppes, however.

It is often assumed that prior to the arrival of Euroamericans, fires were frequent in northern intermountain steppe vegetation. Fedrizzi based recommendations for fire management of steppe vegetation at Craig Mountain on the assumption that the natural fire regime was "nonlethal very frequent," "stand replacing frequent," or "mixed frequent" for bunchgrass and bunchgrass-shrub community types (Fedrizzi 1998:44-49). Johnson (1998) suggests that 80% of the canyon lands of northeastern Oregon experienced low-severity fires in the past, 6% experienced medium-severity burns, and 14% experienced high-severity burns. According to the Forest Service, fires of stand replacement severity occurred with a frequency of 0 to 35 years throughout the steppes and shrub steppes of the West and Midwest (http://www.fs.fed.us/fire/fuelman/firereg.htm, historical natural fire regimes, Version 3.0, November 3, 1999).

This author found little specific data bearing on the fire history of northern intermountain bunchgrass vegetation, however. The conclusion that bunchgrass vegetation burned often is based upon analogy with midwestern steppes or extrapolations from its nearest neighbors, shrub steppe and dry coniferous forest. Gruell (1985) collected 145 accounts of fires in Montana, Wyoming, Idaho, Utah, Nevada, and eastern Oregon, but none of these events occurred in the steppes of the northern intermountain region. It is not clear if this paucity of accounts in steppe reflects infrequent fires or a bias in the historical record. Unfamiliarity with bunchgrasses also led to some errors in interpretation, even among trained observers. The botanist Charles Geyer believed that the caespitose physiognomy was caused by annual frosts and summer fires acting to fragment the grasses, "separating one tuft into several" (Geyer 1846: 288, footnote).

A long-term fire history of Craig Mountain, which rises steeply from the Snake River approximately 30 km southeast of Lewiston, ID, has been reconstructed from charcoal-rich beds and microscopic charcoal in a sediment core taken from Blue Lake (Smith 1983). This site is located at the eastern edge of the intermountain region, at an elevation of 1,035 m, which puts it near the transition between canyon grasslands that rise steeply from the Snake River and forest vegetation at higher elevations. The frequency of macroscopic charcoal in the sediment cores suggests that from 4,300 to 700 years ago, fires severe enough to cause slope erosion burned the open Douglas-fir forests above Blue Lake once every 100 to 350 years.

Although the Blue Lake sediments provide information on the frequency of forest fires at the eastern boundary of the intermountain region, they do not resolve the question of the historical fire frequency of the adjacent steppe vegetation. We do not know if the slopes below Craig Mountain's forests burned as often as the forests. There are reasons to think that they did not. First, since fires move upslope more rapidly than downslope (Daubenmire 1968*a*), it is not warranted to assume that every fire that burned in the forests above Blue Lake also burned the steppe vegetation at lower elevations. Second, where bunchgrasses are widely spaced, as on rocky slopes, fuel continuity may be insufficient to carry fire (Steve Bunting, personal communication, January 29, 2001). Third, aerial photographs of canyon fires taken in the summer of 2000 show that often vegetation dominated by native bunchgrasses did not ignite, even when large fires burned at higher elevations (Dick Walker, personal communication, January 31, 2001.) Thus, although some of the fires that burned trees near Blue Lake

undoubtedly also affected steppe vegetation downslope, the relationship between the frequency of fire in forests and in steppe at this site is not known.

2.1.2. Anthropogenic fires

If the frequency of past fires in the northern intermountain steppe region is difficult to determine, the question of how often those fires were started by Native Americans is equally troublesome. Most examples of anthropogenic burning in the northern intermountain region involve forests or shrub steppe, rather than true steppe vegetation. For example, Lewis and Clark (Thwaites 1959) and the botanist John Leiberg (1900) gave accounts of Nez Perce Indians setting fire to forests, and Shinn (1980) summarized historical accounts of broadcast burning by native people in shrub steppe vegetation in east-central Oregon.

Although there is not a large body of evidence pertaining specifically to the anthropogenic burning of intermountain steppe vegetation, there is ample speculation. Because Indian burning was important in many parts of North America, some authors have assumed it was uniformly important everywhere. Pyne (1982) argued that Native burning was ubiquitous throughout the New World. Following this line of reasoning, Robbins (1999:222), contended that "Indian incendiarism was a significant factor in the burning of grassland and forest alike" throughout the Inland Northwest. This conclusion was based on evidence for anthropogenic fires in California; the Willamette and Puget lowlands; central Oregon; the Blue Mountains; and the valleys of the Walla Walla, Powder, Grande Ronde, and Umatilla rivers. The physical, biotic, and cultural environments of the Northwest were not homogeneous, however, and therefore it is prudent to assume that the importance of human-caused fires varied "from place to place and culture to culture" (Agee 1993:55).

A number of other authors have speculated specifically about the role of Indian fires in intermountain steppes. On the basis of archaeological evidence, Johnston concluded that the Nez Perce deliberately set fire to steppe vegetation to improve the production of food resources and to provide grazing for their horses. Nez Perces reached relatively high population densities in the valley of the Clearwater River; this circumstance led Johnston to speculate that the region's resources could not have supported such high densities without resource management in the form of deliberate burning (Johnston 2000). Daubenmire (1970:7), on the other hand, reached the opposite conclusion. He suggested that since there were no large herds of game animals that could be concentrated by fires and "fire is of little use in warfare when villages are along rivers, the aborigines had little incentive to burn steppe." Similarly, Tisdale (1986:35) suggested that the scarcity of game and lack of shrub encroachment in canyon grasslands of Idaho "may have largely removed motivation for such action." Kaiser also thought that the Indians of eastern Washington rarely burned upland vegetation. His reasoning was based on the large amounts of organic matter in the deep, fertile Palouse soils, which he believed could not have accumulated if aboveground vegetation had been removed by frequent fires (Kaiser 1961). However, many intermountain steppe plants have extensive, deep root systems (Weaver 1917),

which contribute large amounts of organic matter to the soil when they decay (Figure 3). Most of this underground biomass is not affected by burning, so the presence of soils high in organic matter tells us little about past fire regimes.

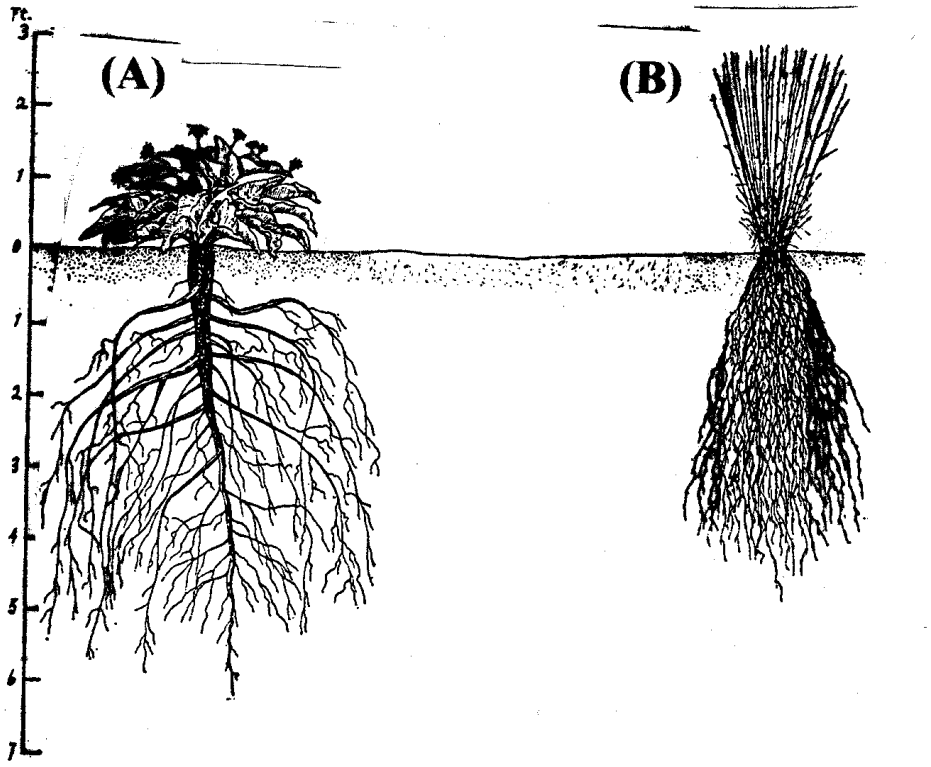

Figure 3. Roots of arrow-leaf balsamroot (A) and bluebunch wheatgrass (B). (After Weaver 1917.) Vertical scale is in feet.

In addition to this speculation, there is some specific data on the question of anthropogenic fires in northern intermountain steppes. During his ethnographic studies, Marshall was told by informants that the Nez Perce periodically set fire to grasslands for a variety of purposes, including enhancing the quantity and quality of food plants, improving winter habitat for elk, and concentrating game (Marshall 1977, 1999 and personal communications, May 8 and January 30, 2001). This is consistent with data from microscopic charcoal in the Blue Lake sediments, which indicate that light surface fires became more prevalent in the vicinity of Craig Mountain about 700 years ago when Nez Perce activity in the area intensified (Smith 1983).

Thus, data from anthropological studies and sediment cores suggest that Native Americans in the northern intermountain region did set fire to steppe environments. The frequency and intensity of these fires are not known, however.